xxxxxx 351-2488

1st May 1981,

Dear Mary,

Thank you for sending me the draft of your paper, which I found waiting for me when I got back to London from an Easter holiday in Scotland. (I read a paper on Bell's Theorem at St. Andrews while I was up there!)

First of all let me clear up the point about getting too many dead cats. I ~~would~~ will revert to the spin experiment as described on pages 8 and 9 of my EPR paper, since ~~that~~ this is what you use on p.12a of your paper. Let us denote by a variable S_A the setting of the knob on the A-meter, and by S_B the setting of the knob on the B-meter, so particular values for S_A would be the directions $\underline{a}$ and $\underline{a}'$ in my diagram, and for S_B the directions $\underline{b}$ and $\underline{b}'$. I will use your notation of t_0 = time particles are emitted from source, t_A= the time ~~the time~~ the A-particle hits the A-meter and t_B = the time the B-particle hits the B-meter and assume $t_B > t_A$. Your claim is that the macroscopic state of the A-meter can be changed at a distance instantaneously and nonlocally at the time t_B, by performing the measurement at B at time t_B, and you deduce this from an application of Bell's Theorem.

First comment: The nonlocality demonstrated in Bell's Theorem is not concerned with performing the measurement at B, but with altering the setting of the B-meter, i.e. changing the value of the parameter S_B. I think you are here confusing the case of

Cont/..

nonlocality$_1$ demonstrated by an application of the 1935 EPR argument, with the violation of Locality$_3$ arising from the Bell argument. Notice how I phrase the formulation of Locality$_1$ on p.5 with reference to measurement and of Locality$_3$ on p.8 with reference to the setting of the remote apparatus, in my EPR paper.

In general if a_n is the spin-component of the nth A-particle parallel to a, then we can envisage writing a_n quite generally as a function of the Q.M. state Ψ we are in, some 'hidden variable' additional specification λ of the state of the particles coming out of the source, and the settings S_A and S_B .

Thus $$a_n = a_n(\Psi, \lambda, S_A, S_B)$$

Now Bell's Theorem shows that if Ψ is Ψ singlet for the two spin ½ particles then a_n must in general depend on S_B. So if S_B changes from b to b' some of the a_n's will change from (+1) to (-1).* But this is only true if we change S_B for times between t_0 and t_A. After t_A the state Ψ is no longer ψ singlet, since the mirror-image correlations are destroyed by the interaction of the A-particle with the A-meter at t_A. Compare my discussion of the transition from Ψ_i to Ψ_f at top of my p.18. When Ψ changes from ψ_i to ψ_f this kills any conclusion of a dependence of a_n on S_B by a Bell-type argument. So if at t_B we change S_B from b to b' this no longer has any affect on a_n and in particular will not cause the spin-meter A to change the reading recorded at t_A.

Applying all this to the case of the cat, QM would not predict that after the control variable C (in point 2 of my previous letter) had interacted with the cat, any further change in the value of C could be effected by moving the lid of the box. All that QM would allow us to infer# is that before C interacted with the cat it would have its value changed by moving the lid. But these changes are such that the number of cats which would have died but are saved (this is an example of the sense in which

* and an equal number from (-1) to (+1).

by a reconstructed Bell argument.

Locality$_4$ gets violated on 1/120 A - see p.16, para 3 of my paper) is exactly equal to the number of cats which would not have died but are in fact killed. So we still end up with 50% dead cats. Suppose, however, per impossibile, that we could change the value of C after the interaction with the cat and allow these revised C-values to interact again with the cat. Then the asymmetry you refer to would clearly be imposed by the irreversibility aspect of the first interaction. Indeed with an ensemble of cats in the box, repeated operation of the lid would in the end kill all the cats. This would certainly provide a bizarre version of the 'Bell' telephone! My point 2) was not that this sort of nonlocality is predicted by QM (it isn't) but that even if such nonlocality did occur, it would not enable us to resurrect dead cats.

I am thus unhappy with your argument on p.12a as an additional difficulty for view A.

You also state on line 7, p.12a that "Bell's theorem shows there are no deterministic laws..." But Bell's theorem (in its original version and forgetting about the case of stochastic hidden-variable theories -see my note 11) assumes determinism and uses this to demonstrate nonlocality$_3$.

On p.10, para 2 you do not make it clear that the difficulty for Bell is to assign values to spin-components, which do not depend on what sort of measurement is being performed on the other particle, (so the last line here should read '...any assignment of locally-determined hidden variables...')

On p.11, para 2 you introduce effectively view B and nonlocality$_1$ but since this is directly related to the EPR 1935 paper I feel this interpretation should come directly after your reference to that paper on p.9, para 2.

At the top of p.12 I am not clear how the first version of the Arthur and Bernard argument is supposed to function. What is

Bernard supposed to do to tell whether Arthur has measured the x-spin or y-spin of his particle? There is no way he can find this out whatever measurement he makes just on his particle. Or is this exactly the point you are making? It is not very clear from the phrase 'Bernard does not know which test to...'

On p.10, para 3 and p.11, para 1: I am unable to follow the argument of 'another suggestion for evading the EPR paradox'. I am particularly unclear about the reference to 'conspiracies' at the end of this passage. Is there any reference here to what I call Fine's Conspiracy Models for evading Bell's theorem referred to on p.12 of my paper?

A few very minor points:
p.4, para 2, line 6: 'One or two slits'. Do you not mean two slits which can be opened or closed rather than 'a few slits' which might be suggested!

p.8a, line 2: Do you mean to say 'extra-physical'?

p.8a, line 4: 'The early quantum physicists...' Perhaps you should say 'some of...' since von Neumann, London and Bauer, for example all subscribed to the effect of consciousness.

p.9, para 2: Spin-components measured in units of $\hbar$ not explicitly mentioned.

Having made some criticisms of the paper, let me say at once there are many things that I think you put very well, particularly your criticism of Nagel on p.4, and your whole discussion of the Cat paradox and Wigner's friend. It is really only pages 9-12a that seem to me to involve some confusions.

With best wishes,

Yours,

Michael

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P.S. I have just now received the 'Butterfield' corrections. This does not affect any of my above arguments.